have been published in the local papers. The bamboo forests of Chanda consist of *Dendrocalamus strictus*, the male bamboo, a bushy plant from 20 to 30 feet in height, and affecting the cooler northerly and westerly slopes of Central and Southern India. This is said to be the first time in the history of these forests that a sweet and gummy substance has been known to exude from the trees. The gum has been exuding in some abundance, and it has been found very palatable to the natives in the neighbourhood, who have been consuming it as a food. The occurrence of the manna at this season is all the more remarkable, since the greatest famine India has known is this year visiting the country, and the districts where the scarcity is most keenly felt are in the Central Provinces.

An authentic specimen of this bamboo manna was sent to Dr. Watt, Reporter on Economic Products, Calcutta, and was subsequently handed to me for examination. It occurred in short stalactiform rods about an inch long, white or light brown in colour, more or less cylindrical in shape, but flattened or grooved on one side where the tear had adhered to the stem. It was pleasantly sweet, without the peculiar mawkish taste of Sicilian manna (*Fraxinus rotundifolia*). It was soluble in less than its own weight of water, and the solution when allowed to repose deposited white, transparent crystals of sugar. The manna contained 2·66 per cent. of moisture, 0·96 per cent. of ash, 0·75 per cent. of a substance reducing Fehling solution, and a small quantity of nitrogenous matter. The remainder consisted of a sugar which became inverted in twenty minutes when boiled with dilute hydrochloric acid (1 per cent.), and from its solubility, melting-point and crystalline nature, appeared to be a saccharose, related to, if not identical with, cane sugar. It contained no mannite, the saccharine principle peculiar to true manna.

The bamboos and sugar canes belong to the same natural order of grasses, and perhaps it is not unnatural to expect them to yield a similar sweet substance which can be used as a food; but it is a coincidence that the culms of the bamboo, hitherto regarded as dry and barren, should in a time of great scarcity afford sustenance for a famine-stricken people.

Indian Museum, Calcutta, May 3. DAVID HOOPER.

Solution Theory Applied to Molten Iron and Steel.

I AM pleased to notice that the theory of solution of iron and steel has recently received attention, and that valuable work has been placed before us for consideration by Baron von Juptner (see recent proceedings of the Iron and Steel Institute).

Will you, however, permit me to state that many years ago, in a contribution to the Institute (*Iron and Steel Inst.* 1881), I advocated the theory of solution in the following words:—

"The solution theory is directly applicable to fluid iron and steel, as it is to water. Carbon, phosphorus, &c., are more or less soluble in the fluid metal, just as salts are soluble in water; in both cases the same forces are at work; water, however, at the normal temperature of 60° Fahr., fluid iron about 2500°–3500° Fahr."

"Further, the physical or gaseous theory of solution best explains the facts; the so-called chemical theory of solution is not so applicable. It is difficult to give satisfactory reasons for the union of stable bodies such as carbon and iron, but the gaseous theory of solution apparently does so.

"The difficulty of its complete or further application becomes one of degree only, for no definite distinction can be drawn between gases, liquids and solids, more especially when the latter are heated.

"The quantity of matter dissolved in a given time is simply a function of temperature, and at low osmotic pressure is comparable with that of a liquid evaporating under the pressure of its own vapour" (NATURE, 1892).

"Moreover, it is remarked that ordinary soft steels for sheets, rails, &c., should be so manipulated as to produce a colloid, or, as near as possible, a non-crystalline material, avoiding always the formation of large crystals" (*Iron and Steel Inst.* 1881).

In my practice I have always adhered to the solution theory, finding that it gave the key to the solution of many discrepancies observed in the manufacture of steel, which ordinary analysis, and the usual theoretical deductions therefrom, sometimes failed to explain.

It appears to me, however, that the solution theory requires extension. We have, I think, up to the present only touched upon the surface of the matter, and more extended and deeper research will amply repay those who have already done work in this direction.

In connection with this subject, although perhaps not exactly bearing upon it, there is what may be termed the theory of the crystallisation of steel and iron. A sheet of ice, as is well known, shows, when heated, beautiful structural, or more correctly crystalline, changes. Why should not a steel plate exhibit changes of this kind if similarly treated?

It is evident, as has been remarked of others, that if the sheet of either ice or iron be suddenly cooled at a given temperature, the structure or grain at that temperature will be approximately retained, and that steel of a given chemical composition may give a material of varying physical properties practically governed by the applied temperature, but not, strictly speaking, in accordance with its chemical composition, as usually assumed.

I have lately found that this happens, and have produced steel of four degrees of hardness by mere temperature manipulation, with metal containing only one-tenth per cent. of carbon together with low per cents. of sulphur and phosphorus. I believe also that this has been done to a certain extent by others, but the facts have not, so far as I know, met with the attention of the practical manufacturers of steel.

Newport, Mon., May 16. JOHN PARRY.

THE BACTERIAL TREATMENT OF SEWAGE.

THE discovery made by Schwann, in 1839, that a putrefying liquid swarmed with microscopic living organisms, gave occasion to a long series of remarkable investigations as to the general nature and the life-history of these organisms, and the chemical changes which they produced.

Prominent amongst the names of those who prosecuted these investigations stands that of Pasteur, who, in 1857, drew attention to the nature and causes of fermentative changes produced upon sugar solution, of the putrefactive changes in liquids containing animal substances, and of disease changes in the blood of the living animal, which were produced in the presence of various minute living organisms. He showed that, if these liquids were sterilised by heat, and were then duly protected against receiving solid particles from the air, or from other sources, these changes did not occur; and that contact with air which had passed through a red-hot tube, or had been filtered through a cotton-wool plug, was incompetent to introduce the organisms and to start the above changes.

These researches drew attention to the important part played by the air as a vehicle of the organisms or of their spores, and was supplemented by the researches of Tyndall (1876), who proved that air which had been allowed to remain at rest until its motes had subsided was incompetent to produce putrefaction. Tyndall also proved that boiled sterilised broth, when opened in Alpine air, did not usually putrefy, and that the air near the earth's surface in different localities, and even in the same locality at different times, possessed infective power varying from nil to something considerable. The inference is that the distribution of these organisms and of their spores varies very considerably in any horizontal plane near the earth's surface.

Percy Frankland (1886) determined the number of these living organisms which could be developed from equal volumes of air collected at varying heights from the earth's surface. He made use of hills and cathedral towers for the purpose of collecting his samples, and noted a regular decrease in the number of the organisms which were in the air at greater and greater distances from the earth's surface.

These typical researches render it evident that the organisms and their spores, which are produced at or near the earth's surface, are wafted by natural atmospheric movements to some height, but are constantly

tending to subside, and to sow the organisms broadcast as they descend.

It has been shown by more recent bacteriological investigations that many of these minute organisms are normally present in the living organism, and make their appearance in large numbers in the dejecta. It is therefore not remarkable that sewage, which contains the dejecta of men and animals, as well as the washings of considerable road and other surfaces, should contain micro-organisms and their spores in large number.

The fact that animal dejecta and sewage are inoffensively and gradually resolved into simple chemical compounds by contact with different kinds of soil has long been known, but this resolution has, until recently, been attributed to the purifying action of the earth itself, or of the organisms which it may contain. It is now abundantly proved that the resolving or purifying agents are, in the main, the micro-organisms which were originally present in the dejecta themselves, although undoubtedly organisms derived from the air, and those already present in the soil, contribute to the change when they are present.

The experimental purification of sewage by letting it stand in tanks filled with flints, gravel, coal, coke or other mineral substances, proves that there is no special virtue in soil. These experiments, originally commenced by the Massachusetts Board of Health, in 1887, have been repeated by many public sanitary authorities, and their results have been abundantly verified; and in various localities broken stone, broken slate, broken clay vessels, "ballast" or burnt clay have been successfully employed in the tanks in place of the materials which were originally used.

For the successful and inoffensive treatment of sewage by this means, a preliminary "priming" of the material is necessary. This is effected by allowing it to remain immersed in sewage for several hours daily for a few weeks. Sewage, which is then introduced and allowed to remain for a few hours in the tank containing the "primed" coke or other material, has the amount of its putrescible dissolved matters considerably and rapidly reduced, while its solid, finely-divided fæcal matter is brought into solution, and caused to undergo, in large measure, inoffensive resolution into simple compounds.

In order that these changes may be completed inoffensively, it is necessary that the "primed" coke surfaces shall be frequently placed in contact with air, and the process is therefore an intermittent one. The coke-bed is first filled with sewage, which is then allowed to flow out from the bottom and to draw air into the interstices of the coke. After the coke surfaces have been for several hours in contact with the air, the cycle of processes is then repeated. The treatment of fresh quantities of sewage in the same coke-bed may apparently be continued indefinitely.

The effluent from one coke-bed undergoes a considerable further purification if it is made to undergo similar treatment in a second coke-bed; and if this second contact with the coke surfaces is followed by ordinary sand filtration, such as is usually applied to river-water which is to be used for drinking purposes, an effluent of extraordinary purity is obtained.

The original methods introduced by the Massachusetts experiments, and known as the intermittent aërobic treatment, is sometimes preceded by a preliminary anaërobic treatment. This consists in allowing the sewage to remain quiescent in, or to flow very slowly through, a large tank or channel. A thick, tough scum soon forms upon its surface, and protects the liquid from the air. Under these conditions many of the solid suspended particles of an organic nature pass into solution, and are thus rendered rapidly resolvable by subsequent aërobic intermittent treatment.

The above general description of the bacterial treatment of sewage has been subjected to modification as to details to suit the conditions of particular localities. Thus the sewage is in some places subdivided by suitable mechanical arrangements into drops, and allowed to fall continuously like rain upon the surface of the coke-bed. The bed never becomes full of liquid, since when the sewage has trickled through the coke, and has been exposed to the coke surfaces and to the interstitial air, it is at once allowed to flow away from the bottom of the bed.

That these methods of purifying sewage are correctly described as bacterial has been placed beyond doubt. Any conditions which are unfavourable to bacterial life at once retard the purification, while any treatment of the sewage which sterilises it arrests the purification entirely.

The bacteria in the sewage are considered to be the active agents, producing the changes either directly or indirectly through their products or enzymes. Bacteria and their spores are found to be present in great numbers in sewage. London sewage has been shown by Dr. Houston and others to contain very large numbers of bacteria, varying from about three to six million per

FIG. 1.—*Proteus vulgaris*. Impression preparation from "swarming islands" on gelatine; 20 hours' growth at 20° C. × 3000. (Houston.)

cubic centimetre. It seems probable that many of these bacteria form films, or "swarming islands," on the coke surfaces, similar to those which are produced by their growth upon the surface of a gelatine film (Fig. 1); the period of formation of these films may be assumed to be the period of "priming" already referred to. Probably the coke-bed aids bacterial action largely by furnishing surfaces of attachment to the bacteria, upon which they may alternately be exposed to air and to the sewage. The useful effect of solid surfaces in promoting bacterial action in the case of other similar changes is well-known, and it may be connected with the effect which the surfaces exert in preventing the settling of the bacteria to the bottom of the liquid.

Sewage contains many different species of bacteria, some of which have been described and figured by Dr. Houston.[1] As is seen in Figs. 2, 3, 4, some of these

[1] The illustrative figures in this article have been selected from Reports on "The Bacteriology of London Crude Sewage" and on "The Bacterial Treatment of Crude Sewage," by Dr. Clowes and Dr. Houston, issued by the London County Council (F. S. King and Son); they were originally produced from micro-photographs taken by Dr. Norman from Dr. Houston's cultivations.

bacteria possess motile tail-like flagella, and by the movement of these the minute organisms maintain a rapid progress through the liquid. Bacteria which are devoid of flagella, and cannot traverse free paths in the liquid, are shown in Figs. 5, 6, 7 and 8. In Fig. 9, the spores of these minute vegetable organisms are seen interspersed amongst the organisms themselves. The organisms have

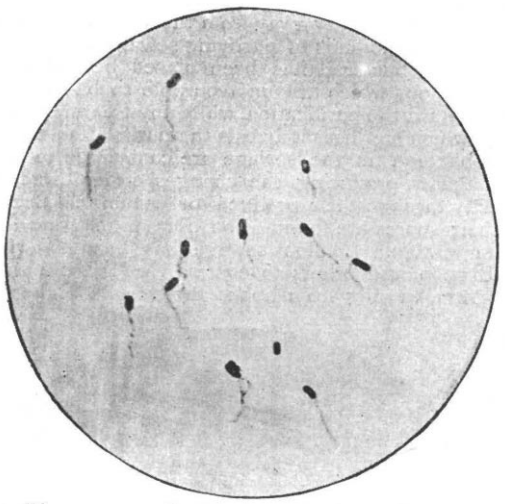

FIG. 2.—"Sewage proteus." Microscopic preparation stained by V. Ermengem's method, showing one flagellum at the end of each rod; from a 24 hours' growth agar culture at 20° C. × 1000.

two methods of multiplying, by fission and by producing spores: the spores have great power of retaining vitality. It is found that none of these bacteria are selectively retained by a coarse coke-bed during the treatment, but that all the species make their appearance in but slightly diminished numbers in the purified effluent from the coke-bed. The average reduction in number of bacteria

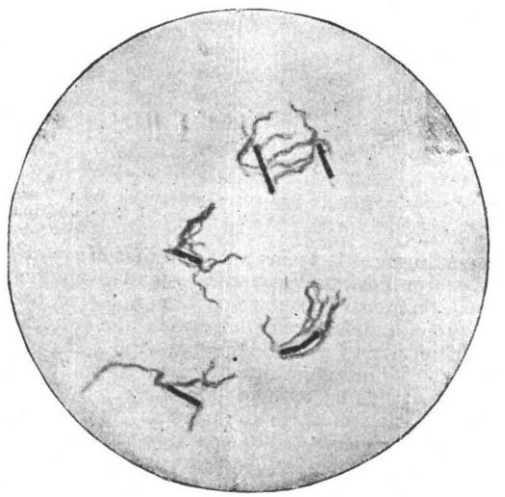

FIG. 3.—*B. mesentericus.* Sewage variety E. Microscopic preparation stained by V. Ermengem's method, showing numerous flagella, from a 20 hours' agar culture at 20° C. × 1000.

suffered by the sewage by one treatment in a coarse coke-bed amounted to only 27·7 per cent. It would therefore appear that the different species of bacteria assist one another in the purifying action, and by producing either contemporaneous or consecutive effects upon the sewage secure its purification: in bacteriological language, their action is either symbiotic or metabiotic, or possibly of both kinds. The organisms seem to establish and maintain a condition of equilibrium amongst themselves in the coke-bed, since attempts to artificially increase the number of certain species have thus far failed.

It appears that in the above processes there is no separation of the bacterial action which takes place in

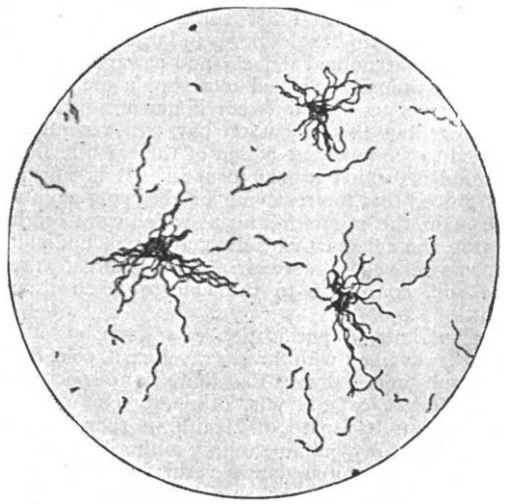

FIG. 4.—*B. mesentericus.* Sewage variety I. Microscopic preparation stained by V. Ermengem's method, showing numerous flagella; from a 20 hours' agar culture at 20° C. × 1000.

the presence of air from that which occurs only in the absence of air, and both processes probably proceed side by side in the open coke-bed. The anaërobic, or so-called "septic," treatment, during which cellulose is slowly resolved with separation of hydrogen and methane, is, however, sometimes made to precede the more truly aërobic treatment.

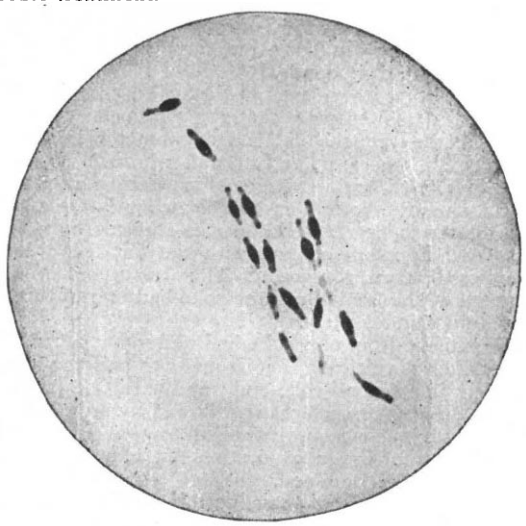

FIG. 5.—*Bacillus subtilis.* × 1500.

One result of the anaërobic treatment is the liberation of large volumes of combustible gas, and this gas has been employed at some works for illuminating purposes on the incandescent principle.

The general products from both processes of bacterial action are carbon dioxide, water, ammonia, nitrogen, hydrogen and methane; and in the aërobic changes the ammonia is subsequently oxidised into nitrite and nitrate.

The experience obtained from several years' experimental bacterial treatment of sewage at several of our largest cities has recently been published.

In 1893 the London County Council constructed an acre coke-bed about three feet in depth at the Barking Outfall of the North London Sewage. This bed has been

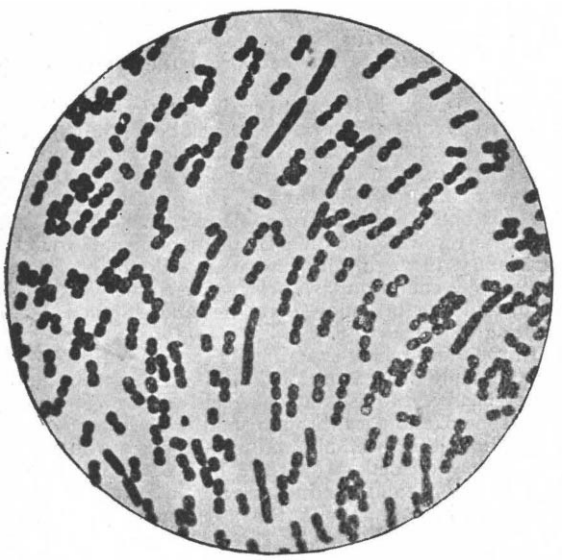

FIG. 6.—*B. subtilissmus*. Impression preparation from a gelatine plate culture. × 1000.

receiving screened and sedimented sewage up to the present time, the process of sedimentation having been assisted by the addition of a small proportion of solutions of lime and of ferrous sulphate. Two years ago the bed was deepened to about six feet. Its purifying action, as measured by the amount of oxidisable matter present in

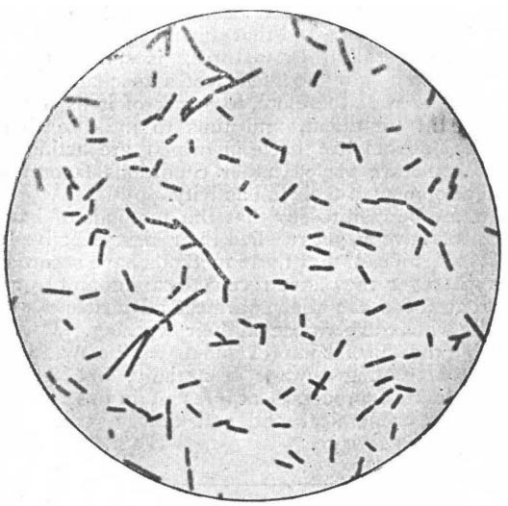

FIG. 7.—*B. mesentericus*. Sewage variety E. Microscopic preparation from a 20 hours' agar culture at 20° C. × 1000.

the raw sewage and in the clear effluent, amounts to 92 per cent., and if the purification is calculated from the clear sewage and effluent, it amounts to 84 per cent. More recent experiments have proved that the treatment of raw, roughly-screened sewage in such coke-beds is satisfactory, but that the capacity of the bed becomes continuously reduced by the deposition upon the coke of mineral matter from road detritus, of particles of straw, chaff and woody matter from the horse-traffic and from the wood pavements. It was, therefore, evident that these matters must be deposited by sedimentation before the sewage was brought into the coke-beds. A comparatively

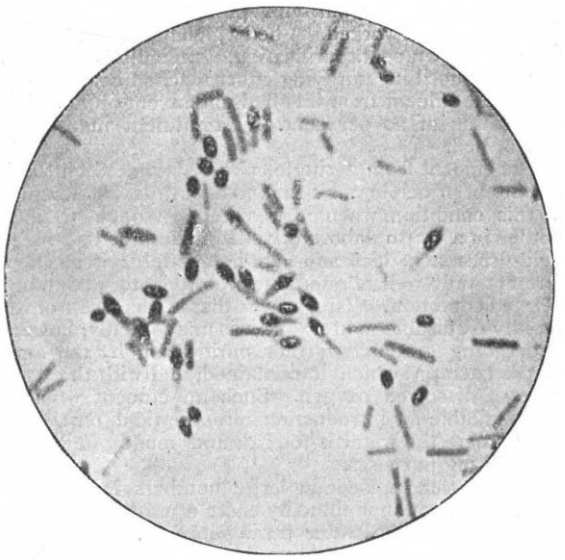

FIG. 8.—*B. enteritidis sporogenes* (Klein). Microscopic double-stained preparation, from a serum culture, showing spores. × 2000.

rapid process of sedimentation suffices to remove these matters, since even the cellulose matters arrive in the sewage in a heavy and waterlogged condition.

It was found advantageous to use coke in comparatively large fragments, about the size of walnuts, since this facilitated the rapid draining of the liquid from the coke,

FIG. 9.—*Proteus vulgaris*. × 1000.

and at the same time increased the sewage capacity of the bed and promoted its efficient aëration. The depth of the beds has been augmented from 4 to 13 feet, and the increase of depth seems to be attended with increase of efficiency. The 13-foot bed has for long periods given a purification from dissolved oxidisable matter of over

60 per cent. It has maintained a most satisfactory state of aëration, since the air drawn from the bottom has contained, on an average, 17 per cent. of oxygen.

About 60 per cent. of the matter which settles from the sewage under ordinary conditions is combustible, and could, therefore, very well be dealt with by a destructor.

The tendency of the coke bacteria beds is undoubtedly to improve in their purifying power with age, provided they are not overworked. A bed which had given for some time a 50 per cent. purification, gradually increased in efficiency until its purifying effect reached nearly 70 per cent. The effluent from this bed underwent an additional purification of 20 per cent. by treatment in a second similar bed.

The effluent from a single coke-bed worked on the intermittent principle was clear and odourless, and remained in this condition when it was kept in open or closed bottles in a warm laboratory. It maintained the life of gold-fish, roach, dace and pike indefinitely: it was therefore not only well aërated, but was able to maintain its aërated condition. This proves that it was free from any rapidly oxidisable matter. It was undoubtedly, however, undergoing gradually further purification by the action of the bacteria which it contained, and with the assistance of dissolved oxygen. Such an effluent would be quite suitable for introduction into the tidal part of the river, where the water is too salt and muddy to be used for drinking purposes.

Bacteria are present in large numbers in the river-water itself, and undoubtedly exert a most useful purifying effect upon the water during its flow. The relation between the number present in the sewage and in the water of the River Thames, below and above locks, is shown by the following estimations made by Dr. Houston. The number of liquefying bacteria included in the total number of bacteria present in one cubic centimetre, and the number of spores of bacteria, are also stated :—

	Bacteria.	Liquefying bacteria.	Spores.
Raw sewage from North London, Feb. to April 1898	3,899,259	430,750	332
Raw sewage from South London, Feb. to April 1898	3,526,667	400,000	365
May to Aug. 1898	6,140,000	860,000	407
Effluent from coke-bed, South London, May to Aug. 1898 ...	4,437,500	762,500	252
[Percentage reduction by passing through coke-bed...	[27·7]	[11·4]	[38]
Lower Thames water, Greenhithe, half ebb-tide, Oct. 1898...	10,000	—	63
Lower Thames water, Barking, low tide, Nov. 1898	34,400	—	89
Upper Thames water, between Sunbury and Hampton, Nov. 1898	5,100	—	56
Upper Thames water, Twickenham, Nov. 1898	3,000	—	18

The results obtained by the experimental bacterial treatment of sewage at Manchester during the last two or three years bears out generally those which have been obtained in London. The treatment has differed in some details from that adopted in London. The particles of coke constituting the coke-beds have been smaller. The coke-beds have been subjected to a larger number of intermittent fillings per day; and the preliminary treatment in an open anaërobic tank has been carried out with advantageous results. The scientific experts who have suggested and watched the experiments state their conviction that bacterial treatment is the treatment which is most suitable for Manchester sewage, but that in order to secure the most effective purification, the coke-beds must have sufficiently frequent and prolonged periods of rest, and must be fed with sewage as free as possible from suspended matter, and as uniform in quality as may be. Preliminary anaërobic treatment is referred to as the best means of securing uniformity in quality of the sewage, and of adapting it to rapid subsequent aërobic purification. Four fillings in 24 hours have been found suitable, if one day's rest in seven is given to each coke-bed; the number of fillings, however, may exceed this without detriment to the bed or to the character of the effluent.

Town sewage is found to arrive at the outfalls at an almost constant temperature throughout the year. It rarely falls below 13° C. And this temperature not only prevents the possibility of the coke-beds being stopped by the freezing of the sewage, but also secures to the bacteria one condition favourable to their action. When a bed is too freely aërated by the passage of frosty air constantly through the interstices of the coke, this favourable condition is, however, seriously interfered with, and the bed may even become stopped by the freezing of the sewage.

In the more recent experiments carried out in America by the State Board of Health, Massachusetts, the tendency has been to use fine coke, and to allow the effluent from the coke to pass through sand The passage of the liquid has either been allowed to take place with the outflow widely opened, so that the bed never fills; or the sewage has been allowed to fill the bed and to remain quiescent in contact with the coke for a time, as in the English experiments. The conclusions arrived at seem to be that the degree of purification obtained by the use of fine coke and sand is very satisfactory, but that the volume of sewage dealt with in a given time is smaller than when larger coke fragments are used, and the tendency seems to be to adopt the larger coke in order to expedite the more rapid drainage away of the effluent.

It will be seen from what has already been said that it is well not to speak of this system of treatment as one of filtration. Filtration ordinarily implies a process of mechanical separation of material suspended in a liquid. The fact that the coke-beds only commence their purifying action after they have been "primed" by repeated contact with sewage, and that this purifying action keeps increasing as the bed "matures," is sufficient to show that the action is by no means of a mechanical nature. It would be well, therefore, to speak of it as a process of bacterial treatment, and thus to indicate that the purifying agents are bacteria, which are acting under control, and are placed under conditions favourable to the development of their full activity.

It would be rash to say that the methods of bacterial treatment have as yet reached their most effective state; but it is significant that these methods have secured converts wherever they have received careful and air trial, and that those are their warmest advocates who have had the widest experience of their working. It is even probable that further improvements will be made in the means of treating sewage bacterially, but it is quite certain that the processes at present in use are able to secure the economical and satisfactory purification of ordinary town sewage. FRANK CLOWES.

THE TOTAL ECLIPSE OF THE SUN.

SINCE the first series of telegrams was received announcing successful observations of the total eclipse of the sun on May 28, all the more detailed reports to hand confirm the universal satisfaction of the various parties at the results. As, however, most of the parties having a definite programme arranged to obtain photographic records, complete details cannot be known until the development of the whole of the plates, and in